Synthesis and Self-assembly of Metal and Semiconductor Nanoparticle-Polymer Composites

Scientific Achievement

We have developed a family of ion-conducting scaffolds based on the self-assembly of ionic liquids. Specifically, ionic liquids based on 1-decyl-3-methylimidazolium salts, $[C_{10}mim^+][X^-]$, self-assemble into a wide variety of architectures that can be controlled via changes in the water content. Small angle X-ray scattering (SAXS) has demonstrated that these physical gels are weakly ordered with no water added, but as the water content is increased, hexagonal perforated lamellae, gyroid structures and 2-D hexagonal structures are formed. As a means to improve the mechanical properties of these gels, a polymerizable ionic liquid, 1-decyl-3-vinylimidazolium chloride $[C_{10}VIm^+][Cl^-]$, was synthesized. Photopolymerization of a binary mixture of the vinyl monomer dispersed in water results in the formation of a chemical gel, thus preserving the mesoscopic structures as a robust polymer. We have demonstrated that these physical and chemical ionogels, in turn, can be used to template the *in situ* synthesis of nanoparticle arrays of controlled morphology and organization.

Significance

Controlling the spacing (and thus, the communication) between metal and semi-conducting nanoparticles in a nanostructured ion-conducting framework offers considerable potential in fabricating "next-generation" optoelectronic or photovoltaic materials. The ability to control the lattice dimensions of these materials via solvent conditions regulates the internal packing arrangement of the nanoparticles and hence the collective properties of the nanoparticle-ionogel composites. We have synthesized several tunable, nanostructured ionic liquid gels where subtle changes in their tiny channels both trap and order metal (Au) and semi-conducting (CdS, PbS) nanoparticles. These composite materials have applications for the fabrication of novel photonic materials and all 'solid-state' solar cell devices where the spacing between nanoparticles can be tuned for optimum photovoltaic efficiency. This work has been published in *Small* **2005**, 1, (7), 754, and more recent results have been submitted for publication in *J. Am. Chem. Soc.*

Performers

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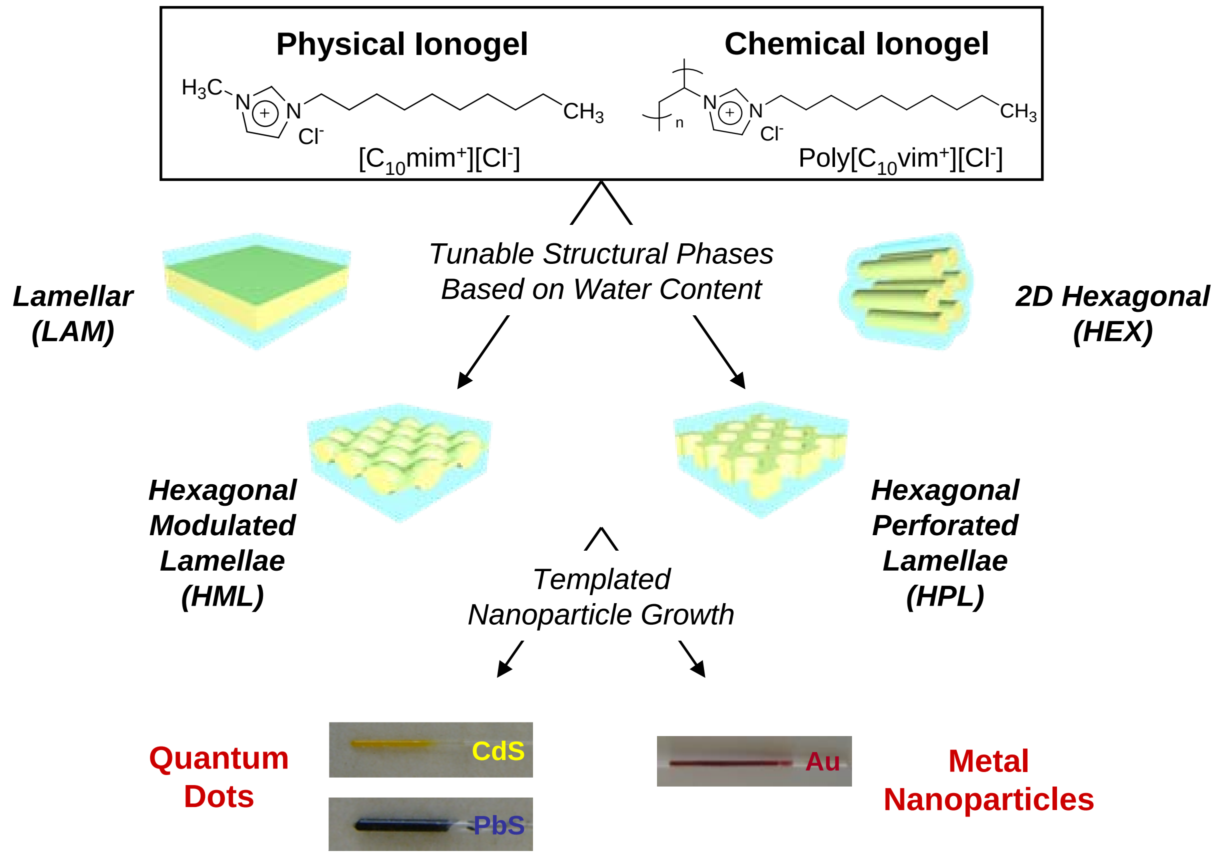
Synthesis and Self-assembly of Metal and Semiconductor Nanoparticle-Polymer Composites

- We have synthesized tunable, soft nanostructures that both template and organize metal and semi-conducting nanoparticles.



- Controlling the morphology and internal packing arrangement of metal and semi-conducting nanoparticles lays the groundwork for the fabrication of "next-generation" optoelectronic or photovoltaic materials.

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